EA-6B HVOF-Coated Landing Gear: Post-Deployment Inspection Results

Tai Ngin
Materials Engineer
NAVAIR FRCSE, 43410

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Outline

- Background
- HVOF Procedure
- Previous Results
- EA-6B Results
- Future Work

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Background

- Electrolytic hard chrome (EHC)
  - Wear resistance
  - Corrosion resistance
- Uses hexavalent chromium (Cr^{6+})
  - Carcinogen, OSHA controlled
  - Expensive to dispose

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Background

- IPT's for chrome alternatives
  - HCAT: Hard Chrome Alternatives Team
  - ESTCP: Environmental Strategic Technology Certification Program
  - JG-PP: Joint Group on Pollution Prevention
- Validation Project: HVOF Thermal Spray
  - Environmentally acceptable
  - Superior performance to EHC

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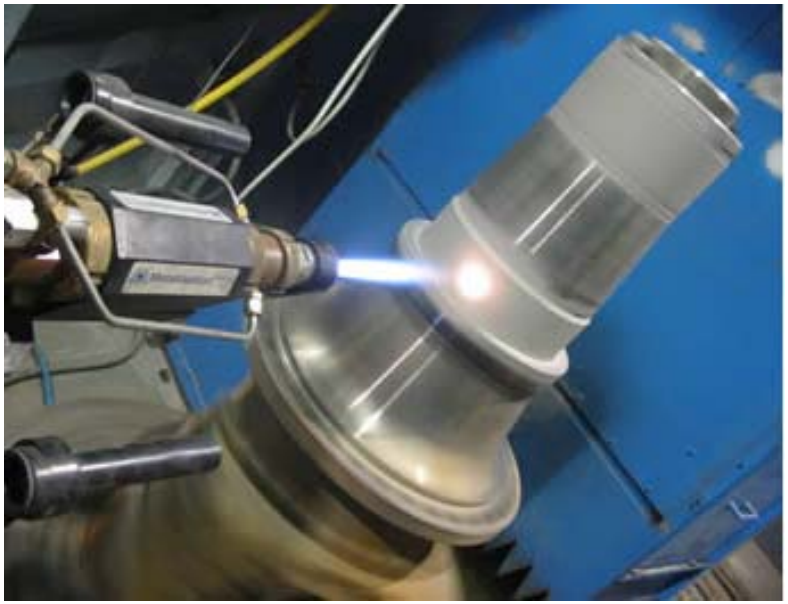
Background

- High Velocity Oxygen Fuel (HVOF)
  - Environmental Coatings
  - Wear Resistant Coatings
- FRCSE Applications
  - F404, F414, J52, TF34
  - Drive shafts, combustor cans



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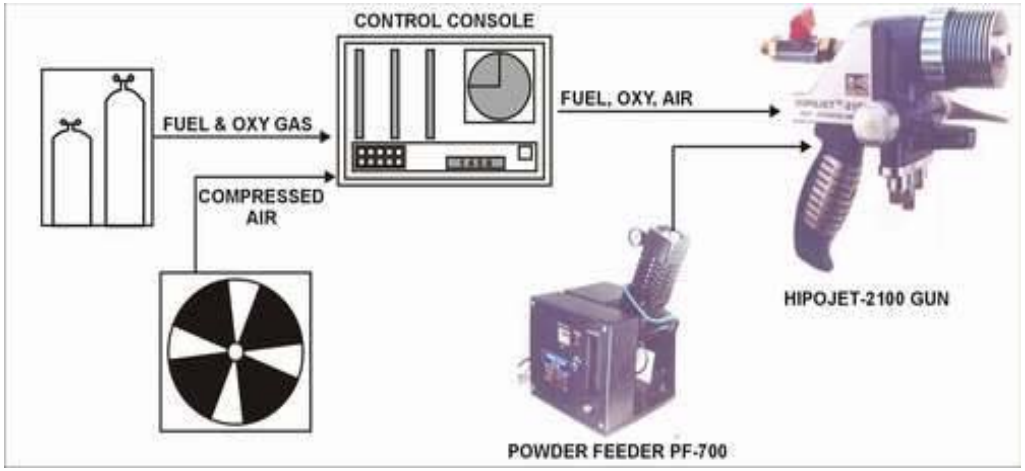
HVOF Procedure

- HVOF Process
  - Combustion of fuel gas and oxidizer (accelerant gas)
  - Feed powder into supersonic gas stream
  - Impact particles onto surface with high temperature and high velocity



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HVOF Procedure

- HVOF Advantages
  - Low porosity
  - High hardness
  - High adhesive bond strength
  - Higher density
- Fits into NAVAIR LEAN Processes
  - Increases throughput
  - Decrease turn around time
  - Reduce costs and simplifies work processes

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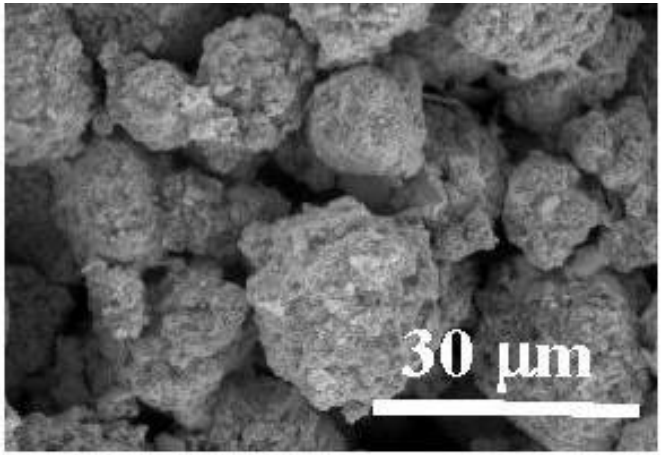
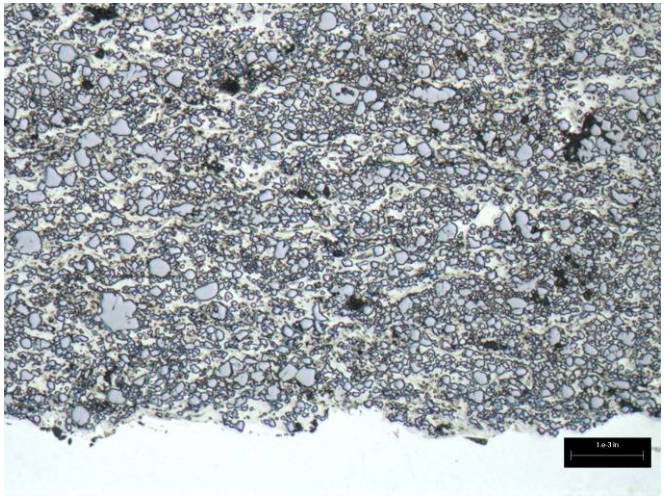
HVOF Procedure

- HVOF Coating
  - METCO DIAMALLOY 2005 NS
    - 83WC-17Co powder mixture
  - Advantages over EHC
    - Hardness
    - Wear Resistance
    - Fatigue Resistance





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HVOF Procedure

- Concerns for HVOF
  - Unknown response for:
    - Carrier-based landings
    - Saltwater corrosive environments
    - Coating susceptible to aqueous and gaseous corrosion
  - Require validation and demonstration in actual naval environments

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Previous Work

- Timeline
  - 10/1999: EA-6B Landing Strut HVOF coated
    - Spalling issues
    - High strains at large stresses
    - Flight clearance on hold
  - 09/2004: EA-6B successfully landed on USS Carl Vinson
    - HVOF coating successful
    - Major project milestone

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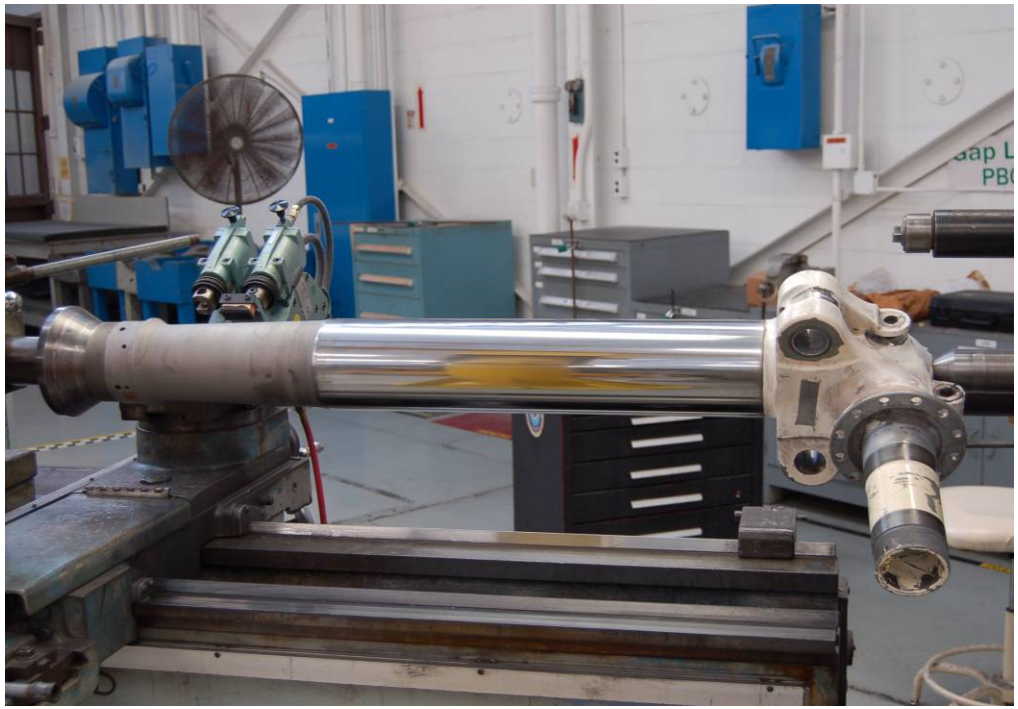
EA-6B Landing Gear

- Current Landing Gear Strut Piston
  - AISI 4330 V Mod
    - σ_Y = 180-185 ksi
    - σ_{UTS} = 220-240 ksi
  - Coated
    - METCO DIAMALLOY 2005 NS
  - Ground finished
    - Ra = 8-16 μin
  - Superfinished
    - Ra = 2-4 μin



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EA-6B Results

- EA-6B (163395) Tours of Duty
  - 2004-2005 VAQ 138/142
  - 2005-2009 VAQ 209 (Reserve Squad)
- Relatively short time-at-sea
  - 153 Catapult shots
  - 154 Arrested landings

Year	Flight Hours	Landings
2004	33	10
2005	605	207
2006	543	177
2007	192	85
2008	109	54
2009	70	38
Total	1552	571

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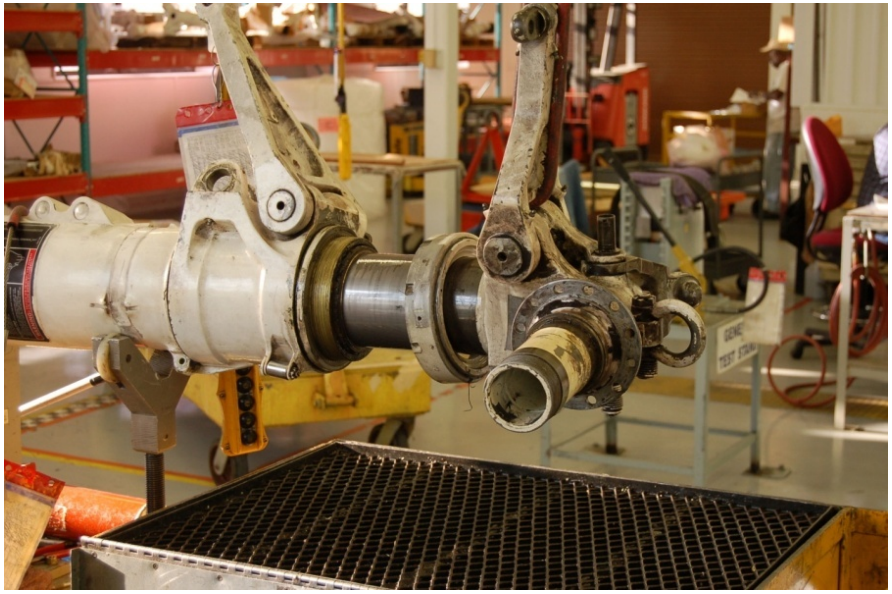
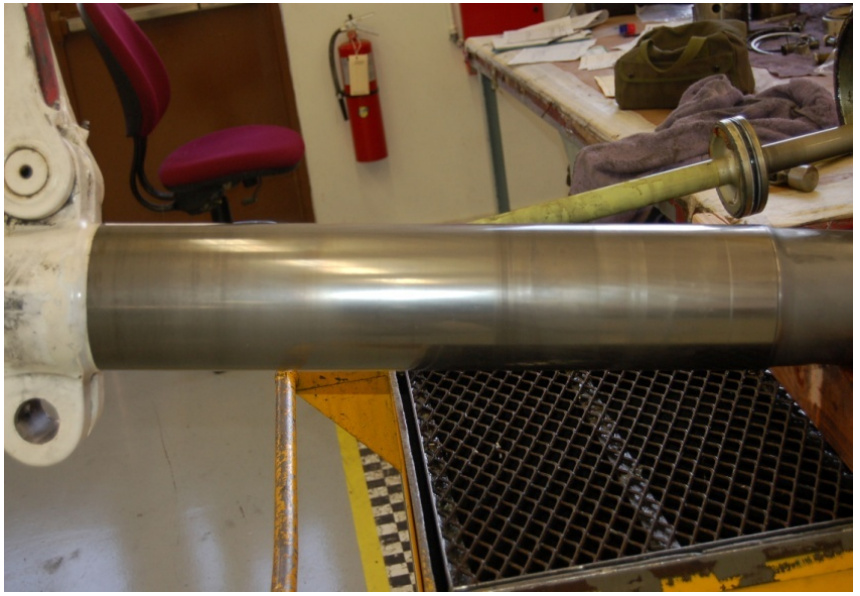
EA-6B Results

- Strut Disassembly
  - Performed due to leak in lower seal



HVOF coated axle and piston during tear down



HVOF coated piston during disassembly

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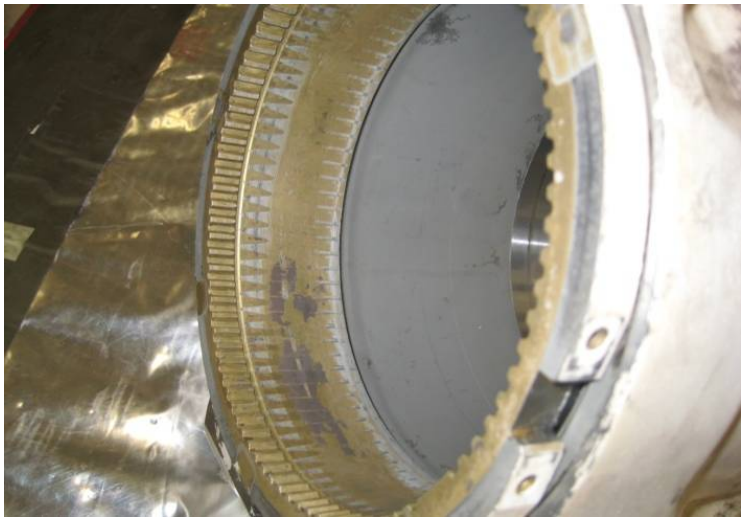
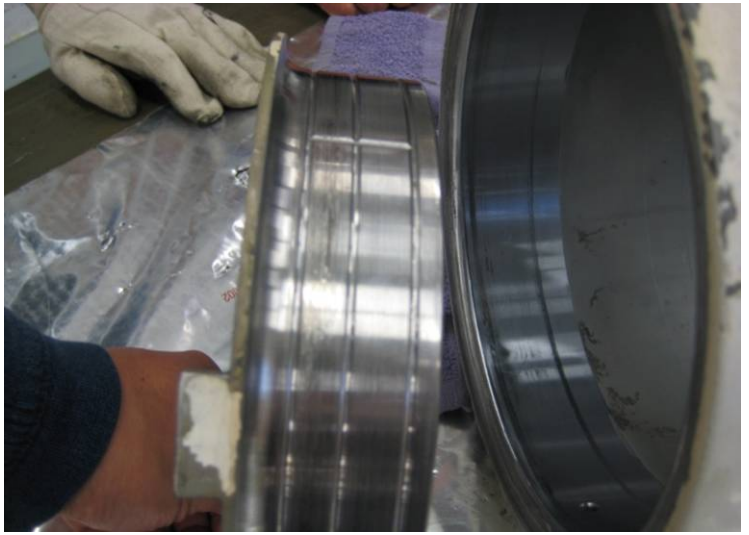
EA-6B Results

- Collar Assembly
  - No indications of wear or other damage





EA-6B Results

- Collar Assembly
  - Roughness check

Chrome plated area
Surface finish Ra = 6-7 µin

HVOF coated area
Surface finish Ra = 7 µin;
Ra = 10-11 µin at outer most edge shown

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EA-6B Results

- HVOF Axle

HVOF on Axle Journals, edges in good condition, coating appeared to be in very good condition

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EA-6B Results

- Collar Bushing
  - The original item was discarded after disassembly
  - Operators reported part corroded
  - Corrosion typical for this part in service.

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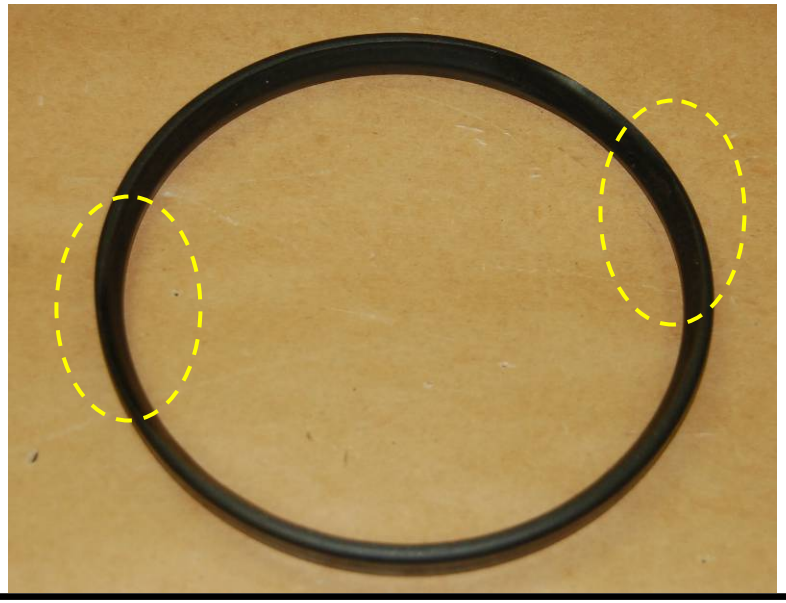
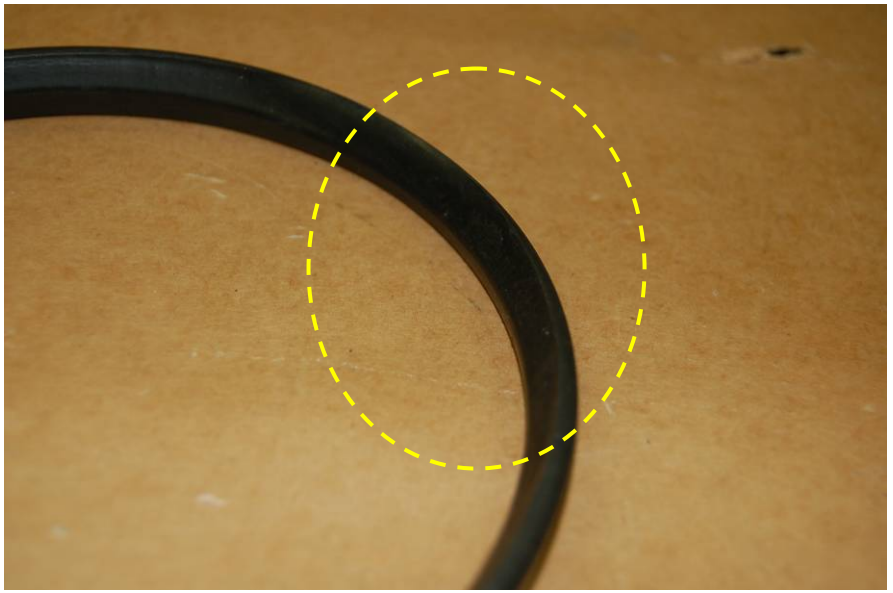
EA-6B Results

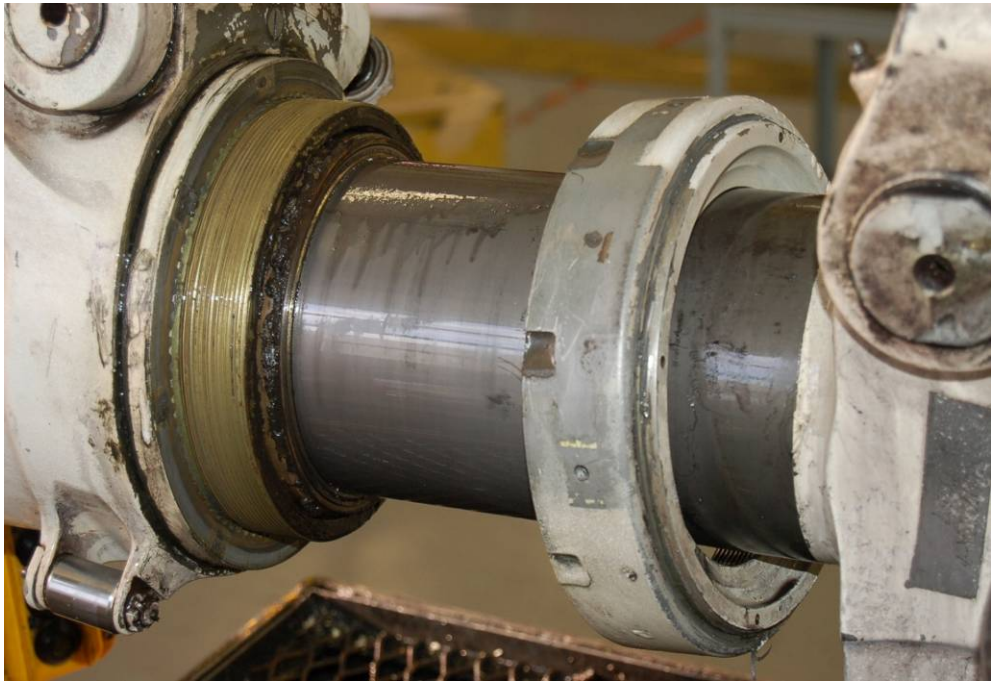
- Failed Seal
  - Seal wear (“flat spots”) at 0° and 180°
  - Possible service in Middle East: sand entrapment / intrusion issues
  - Failure analysis will be performed by Trelleborg Sealing Solutions (POC: John Nash)





EA-6B Results

- Strut Disassembly - Barrel
  - Visual Inspection
    - Roughness Check
  - Clean
  - Vapor Degrease
  - Fluorescent Penetrant Inspection (FPI)
  - Re-superfinish
    - Recheck roughness



Disassembly of collar and seal retainer in location of leak

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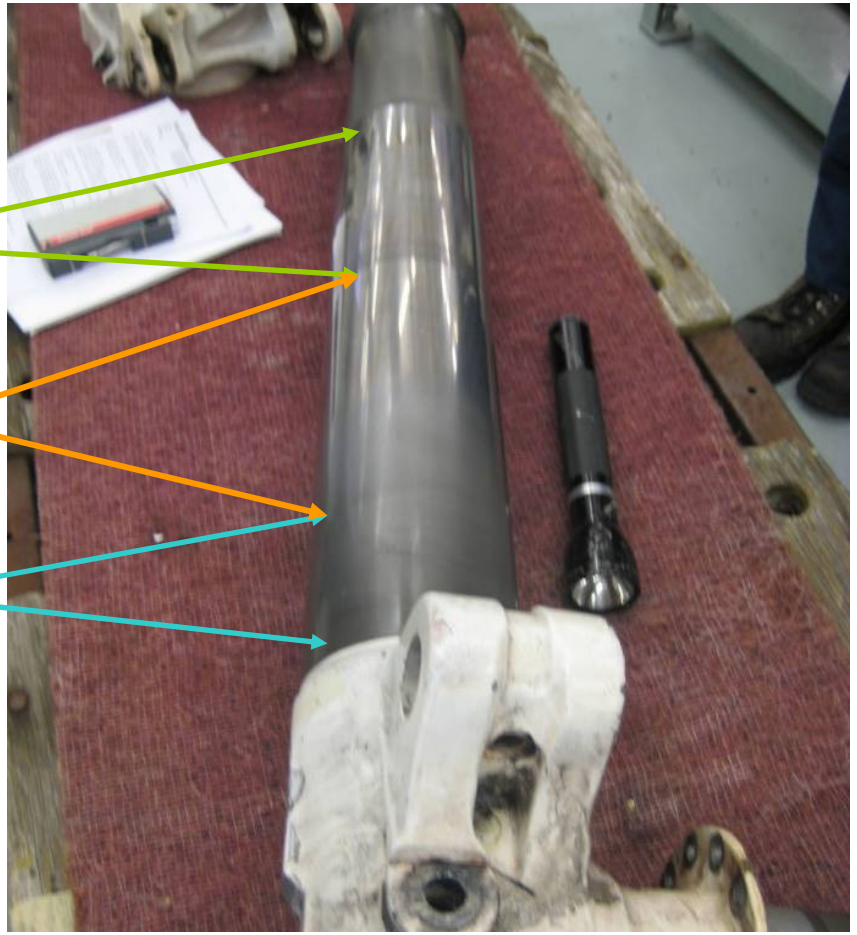
EA-6B Results

- HVOF Piston Surface
  - Roughness check

Surface finish measured Ra 3-4 µin

Surface finish Ra 8-10 µin in center section

Surface finish measured Ra 11-18 µin in area 2” to 8” from base



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EA-6B Results

- HVOF Piston Surface
  - Upper Seal Area

Finish Roughness (Ra) = 2-3 µin

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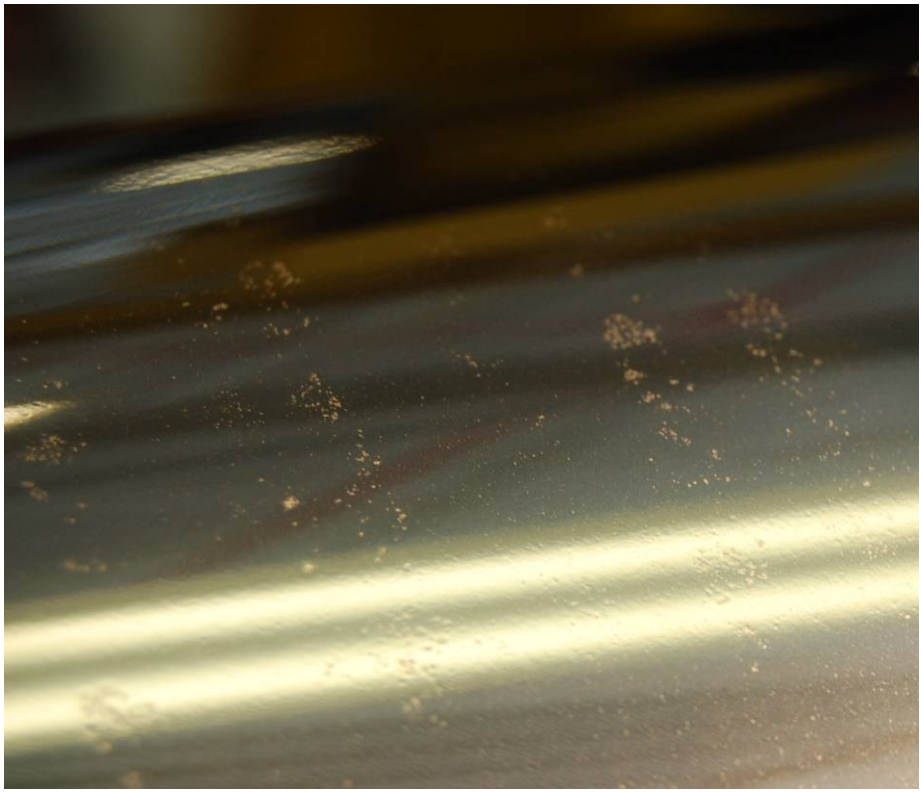
EA-6B Results

- HVOF Piston Surface
  - Lower Seal Area

EA-6B Results

- Corrosion issues
  - FPI initially found no indications
  - After superfinishing, pits found in the coating
  - Co binder highly susceptible to salt corrosion



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Future Work

- First/Best option: Keep Current Coating
  - Re-superfinish current pitted HVOF coating
- Goal: Remove pits, establish Ra of 2-4 μin
  - Want coating thickness above minimum tolerance
  - If not, then part is in a state of Functionally Unusable Component Technology

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Future Work

- **Second/Last option: <u>Apply New Coating</u>**
  - Grind pitted coating to parent metal
  - Recoat the part to return to service
    - Apply chrome coating -OR-
    - Reapply HVOF coating
- Complications
  - Future HVOF coating choice
    - DIAMALLOY 2005: 83WC-17Co
    - AMDRY 5843 (AMS 2447-9): 86WC-10Co-4Cr
  - FUNDING!?!!
    - *“Hubba, hubba, hubba, money, money, money…who do you love?”*

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Questions?

Due to NAVAIR restrictions, responses to questions are not authorized.

Tai Ngin
(904) 542-2451 x141